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LISTS OF SPECIES

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Checklist of bats (Mammalia, Chiroptera) from Tocantins and Bahia, Brazil: a gradient from Cerrado, Caatinga and Atlantic Forest

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Abstract: Herein we present a list of bat species in a gradient of physiognomies, from the Cerrado to the Caatinga and to the Atlantic Forest, between Tocantins and Bahia, two of the most poorly bat-sampled regions in Brazil. A total of 30 species (26 for Bahia and 13 for Tocantins), were recorded. We report, for the first time, two species of bats from Tocantins: *Anoura geoffroyi* (Phyllostomidae) and *Cynomops planirostris* (Molossidae). Our study increases to 41 the number of bat species for the Caatinga of Bahia, including two new formal reports for this region (*Artibeus fimbriatus* and *Molossus rufus*).

Key words: mammals, Brazilian biomes, bat inventory, regional list, north and northeast Brazil

INTRODUCTION

Chiroptera is one of the most diverse mammal orders in the world, including 18 families, 202 genus and 1120 species (Reis et al. 2007), which represents about 22% of the total number of mammals worldwide (Simmons 2005).With the employment of new sampling techniques, increase in sampling effort and number of researchers, besides systematic reviews and description of new species, the number of known species in Brazil is still increasing (Tavares et al. 2008; Bernard et al. 2011; Paglia et al. 2012, Nogueira et al. 2014). Following the newest reports, nine families, 68 genera and about 178 species (Nogueira et al. 2014) are recorded for Brazil, exceeding previous estimates.

Although Brazil is the second richest bat species country in the world, information on bat diversity and distribution within the country is still lacking (Bernard et al. 2011; Gregorin et al. 2011). According to Bernard and collaborators (2011), there is no record of bat species in 60% of our country and none of the Brazilian biomes can be considered adequately surveyed. The second most poorly surveyed biome in Brazil is the Caatinga, of which 52% has already been destroyed. Although there are bat records for 41% of the Cerrado biome, Tocantins and western Bahia are very poorly surveyed states.

Similar results were presented by Aguiar and Zortéa (2008): about 103 bat species from nine families were recorded for the Cerrado biome, being its northern portion the most poorly surveyed (Tocantins, southern Maranhão and Piauí and western Bahia). A compilation by Silva and Nascimento (2008) reported 89 bat species from eight families for the Caatinga biome. According to the recent guides and reports, 54 species are estimated for the state of Tocantins and 90 for Bahia (Nunes et al. 2005; Gardner 2008; Tavares et al. 2008; Bezerra and Marinho-Filho 2010; Gregorin et al. 2011; Peracchi et al. 2011, taking into account only data from published references). For Bahia, about 60 species have been recorded in the rainforest of its southern part (Faria et al. 2006; Falcão 2007) and 39 in the Caatinga (Oliveira et al. 2003; Astúa and Guerra 2008; Sbragia and Cardoso 2008; Silva and Nascimento 2008; Rios et al. 2008 – excluding fossils).

As Brazil is experiencing large investments in infrastructure projects due to government policies, opportunities to sample poorly surveyed areas have been created, resulting in fauna inventories and new records (Bernard et al. 2011). So, as a result of an environmental impact assessment for a linear infrastructure project, we present a list of species in a gradient of physiognomies, from the Cerrado, to the Caatinga and to the Atlantic Forest, between Tocantins and Bahia, as a contribution to increase knowledge on bats distribution in two of the most poorly sampled Brazilian regions. We also report for the first time two species of bats from Tocantins and review the number of bat species for the Caatinga of Bahia.

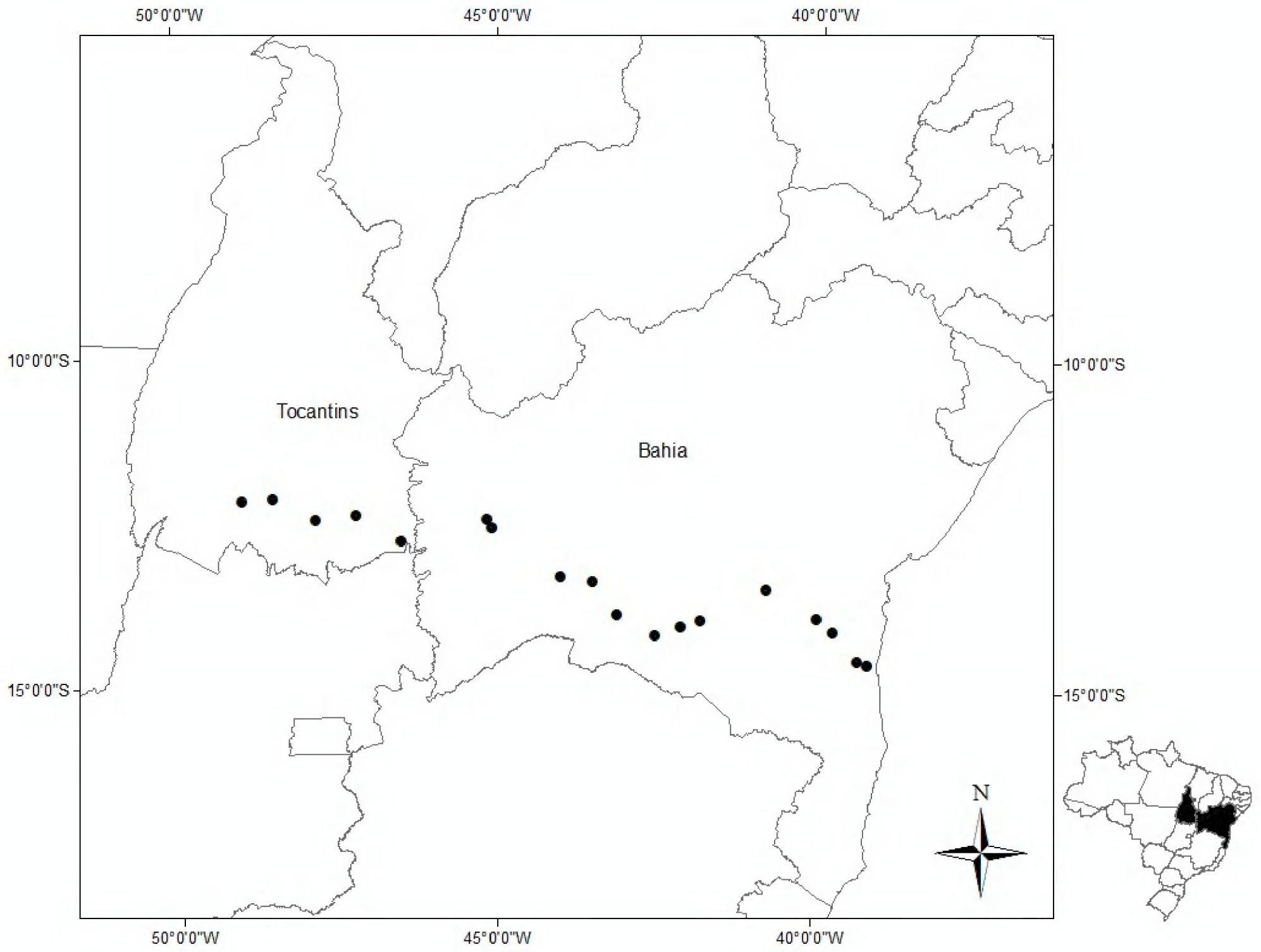

Figure 1. Sampling sites from left to right: 1. Figueirópolis, 2. Peixe, 3. Paranã, 4. Conceição do Tocantins and 5. Combinado, Tocantins; 6. São Desidério 9, 7. Desidério 10, 8. São Félix do Coribe, 9. Serra do Ramalho, 10. Riacho de Santana, 11. Caetité, 12. Lagoa Real, 13. Brumado, 14. Manoel Vitorino, 15. Jequié, 16. Itagibá, 17. Uruçuca and 18. Ilheús, Bahia.

As estimates indicate that between 30 to 52% of the Caatinga and 55% of the Cerrado have already been converted into pasture and agriculture (Aguiar and Zórtea 2008; Bernard et al. 2011), we understand that this sort of data is valid to obtain knowledge about fauna diversity and distribution as well as up-to-date regional species lists for conservation.

MATERIALS AND METHODS

Field works were conducted from 30 September to 27 October 2009 and 1 December 2009 to 17 January 2010, in 18 study areas, five in southwestern Tocantins and 13 in southwestern to southeastern Bahia (Figure 1). Following Köppen, the climate is classified as tropical with dry season (AW) for Figueirópolis, Peixe, Paranã, Conceição de Tocantins, Combinado, São Desidério, São Felix do Coribe, Serra do Ramalho, Riacho de Santana, Caetité, Lagoa Real, Brumado, Manoel Vitorino and Jequié; and as equatorial (AF) for Itagibá, Uruçuca, Ilhéus. The mean temperature for each study area is given in Table 1. The sampled areas were distributed along 1,050 km from Tocantins to Bahia. The sampled localities were chosen according to the fauna monitoring plan during an environment impact assessment.

The geographic coordinates, remnant areas (hectares) and physiognomies of each study site are presented in Table 1. Detailed information on main vegetation in the remnant areas is given in the appendix.

Sampled areas in Tocantins include Cerrado physiognomies, from arboreal to grassland areas, riparian and deciduous forests. Some extensive areas of preserved Cerrado were found in Figueirópolis and Peixe, but deforestation, selective cut, fire, agriculture and pasture were observed in the remaining study sites.

Sampled areas in Bahia harbored Cerrado physiognomies, deciduous forest, Caatinga, semi-deciduous forest and rainforest, most of them covered with secondary vegetation. In Bahia, the Cerrado areas suffered from fire, selective cutting and deforestation; deciduous forests were being replaced with agricultural activities; pasturing, deforestation, selective cutting, hunting and mining activities were found in the Caatinga and

Table 1. The geographic coordinates, remnant area (hectares) and physiognomies of each study site from Tocantins and Bahia, Brazil.

					Mean temperature (ºC)	
Municipality	**Physiognomies**	**Area (ha)**	**Latitude (S)**	**Longitude (W)**	**Dry season**	**Rainy season**
Figueirópolis / Fi	OAS	2,948.29	12°11′04″	048°57′38″	28 (*n* = 5 days)	27.6 (*n* = 8 days)
Peixe / Pe	OAS+RF	1,563.97	12°09′28″	048°28′19″	27.9 (*n* = 10 days)	27.6 (*n* = 8 days)
n / Pr	SP	2,466.77	12°29′08″	047°48′49″	27.6 (*n* = 4 days)	-
Conceição de To / CT	SP	788.11	12°24′24″	047°11′08″	27.8 (*n* = 8 days)	-
Combinado / Co	DF	653.13	12°48′30″	046°28′44″	26.4 (*n* = 9 days)	25.3 (*n* = 8 days)
São Desidério 9 / SD9	OAS	4,281.72	12°28′52″	045°09′10″	27.9 (*n* = 12 days)	26.5 (*n* = 8 days)
São Desidério 10 / SD10	OAS	2,835.93	12°36′20″	045°04′07″	27.9 (*n* = 12 days)	25.7 (*n* = 12 days)
São Félix do Coribe/SFC	DF	1,946.89	13°21′22″	043°59′52″	29.2 (*n* = 6 days)	25.8 (*n* = 10 days)
Serra do Ramalho / SR	OAC+SFRF	2,815.75	13°26′00″	043°30′50″	28.7 (*n* = 9 days)	27.1 (*n* = 10 days)
Riacho de Santana / RS	OAC	-	13°56′03″	043°07′38″	26.1 (*n* = 9 days)	24.8 (*n* = 10 days)
Caetité / Ca	TAC	1,689.86	14°14′46″	042°31′20″	24.4 (*n* = 4 days)	22.3 (*n* = 18 days)
Lagoa Real / LR	TAC	1,943.04	14°06′08″	042°07′29″	25.9(*n* = 13 days)	24 (*n* = 10 days)
Brumado / Br	TAC	1,743.48	14°00′03″	041°48′48″	26.2 (*n* = 8 days)	26.7 (*n* = 10 days)
ManoelVitorino / MV	OAC	2,133.37	13°31′02″	040°47′32″	24.6 (*n* = 9 days)	24.5 (*n* = 10 days)
Jéquié / Je	SF	1,880.25	13°57′31,8″	039°59′47″	23.2 (*n* = 3 days)	24.8 (*n* = 10 days)
Itagibá / It	RF	2,744.57	14°09′22″	039°45′31″	25.3 (*n* = 8 days)	25.7 (*n* = 9 days)
Uruçuca / Ur	RF	2,617.99	14°36′01″	039°21′26″	25.8 (*n* = 7 days)	26.2 (*n* = 10 days)
Ilhéus / Il	RF	2,090.08	14°39′21″	039°12′27″	25.9 (*n* = 7 days)	26.7 (*n* = 9 days)

Cerrado: OAS: open arboreal savanna, OAS+RF: open arboreal savanna + riparian forest, SP: savanna park; DF: deciduous forest; Caatinga: OAC: open arboreal Caatinga, SFRF: São Francisco riparian forest, TAC: thick arboreal Caatinga; SF: semi-deciduous forest; RF: rainforest.

semi-deciduous forests; similarly, selective logging, pasturing, mining and cabruca forest (agroforestry systems in which cocoa trees are planted under the forest canopy for shade) were observed in rainforests.

Bats were captured using mist nests placed 0.5 m above the ground and set at potential flight corridors or edge of remnants, near small rivers, shelters or food sources. Five mist nets (7 × 4 m) were opened at dusk and kept for 6 h during a period of four days in each study area. The total effort was 3,360 m^2·h for each one of the 18 study sites. Additionally, shelters were searched for individuals for 4 hours/study site. The only external measurement taken in field was the length of forearm (mm). In addition, we recorded the weight (g), and the following population data: age, sex, and reproductive condition. The collected individuals were fluid-preserved (ethanol 70%) with their skull removed and the identifications of the specimens were confirmed by a specialist. They were housed at the scientific collection of the Zoology Department, Paraná Federal University UFPR, Seção de Mamíferos (DZUP/CCMZ). Nomenclature follows Nogueira et al. 2014. Only data on collected specimens identified by specialists were included in this report.

RESULTS

As a result of the total sampling effort, 664 individuals belonging to 30 species, seven subfamilies and four families were captured (Table 2). *Carollia perspicillata* was the most common species, corresponding to 46% of the total captures, distributed in nine localities, followed by *Artibeus planirostris* (11%, seven localities) and *Glossophaga soricina* (7.4%, eleven localities). *Desmodus rotundus, Phyllostomus hastatus* and *Platyrrhinus lineatus* represented between 3.2% and 2.0% each, occurring in eight to nine localities.

For Bahia samplings alone, 588 individuals and 26 species were captured in 13 sampling sites (Table 2). *Carollia perspicillata* was the most common species (50.7%, seven localities), followed by *A. planirostris* (12%, six localities), *Phyllostomus discolor* (6.8%, four localities) and *G. soricina* (6.5%, seven localities). Areas with the highest number of species were Uruçuca (16 species, 193 individuals) followed by Jequié (15 species, 51 individuals), Ilhéus (14 species, 131 individuals) and Itagibá (8 species, 145 individuals), all in the Atlantic Forest (Figure 1). In relation to the physiognomies, the rainforest was the richest one, with 21 species and 469 individuals, followed by the semi-deciduous forest (15 species, 51 individuals), Caatinga (14 species, 49 individuals) and deciduous forest (6 species, 14 individuals). Only one species was captured in the Cerrado from western of Bahia (five individuals).

For Tocantins samplings, 76 individuals and 13 species were surveyed in five sampling sites (Table 2). *Glossophaga soricina* was the most common one (14.5% in four localities), followed by *C. perspicillata, D. rotundus* and *P. hastatus* (11.8% each, in four to two localities). *Molossops temminckii* (10.5%) and *P. lineatus* (9.2%) were also common, being the former present in all five sampling sites. Areas with the highest number of species were Conceição do Tocantins (9 species, 24 individuals), followed by Paranã (eight species, 15 individuals), all in Cerrado areas (Figure 1). The Cerrado areas were richer, with 13 species and 58 individuals, followed by the deciduous forest, with six species and 18 individuals; however, only one site was sampled in the deciduous forest against four in the Cerrado.

Two species of bats are reported for the first time

for Tocantins: *Anoura geoffroyi* (Phyllostomidae) and *Cynomops planirostris* (Molossidae). Four adults of *A. geoffroyi* were captured in Paranã: three in October and one in December 2009. Three individuals of *C. planirostris* were captured in Conceição do Tocantins: one in October and two in December 2009 (Table 3).

DISCUSSION

According to Aguiar and Zortéa (2008), the most common species in the Cerrado biome are *Desmodus rotundus*, *Glossophaga soricina*, *Carollia perspicillata*, *Phyllostomus hastatus*, *Artibeus lituratus*, *Platyrrhinus lineatus*, *Sturnira lilium* and *Anoura caudifer*, in decreasing order. As a result of a 91,275.6 h·m² sampling effort in five different Cerrado physiognomies — humid forest borders, Cerrado *sensu stricto* and Cerrado over stone rich ground, the most frequent species in the Serra Geral Tocantins Ecological Station were *P. lineatus* and *C. perspicillata*, representing 23.5% and 15.4% of the total captures (Gregorin et al. 2011). Even comparing

Table 2. List of species, conservation status, and distribution of captured specimens. The material is housed in the Zoology Department, Parana Federal University UFPR, Mastozoological session (DZUP/CCMZ). Abbreviations for occurrence sites as in Table 1. Status *MMA, **IUCN, VU = vulnerable, DD = data deficient.# First formal record for the species in Tocantins; ## first formal record for the species in the Caatinga of Bahia.

	Occurrence sites (n = number of individuals)																		
Species	**Fi**	**Pe**	**Pr**	**CT**	**Co**	**SD9**	**SD10**	**SFC**	**SR**	**RS**	**Ca**	**LR**	**Br**	**MV**	**Je**	**It**	**Ur**	**Il**	**Specimens collected (DZUP/CCMZ)**
Phyllostomidae																			
Desmodontinae																			
Desmodus rotundus	2	1	1		5						1		2		2	1	6		4 (f:1136; m:1078, 1092,1099)
Diphylla ecaudata										1					1				2 (f:1114, 1120)
Lonchorhininae																			
Lonchorhina aurita															1		1		1 (m:1128)
Phyllostominae																			
Mimon crenulatum										3						1			1 (m:1081)
Phyllostomus discolor				3	2									1	7		15	17	4 (f:1153; m:1097, 1098, 1157)
Phyllostomus hastatus	1	1		4	3			1				1		1	1		1		4 (f:1134; m:1109, 1108, 1158)
Trachops cirrhosus																		1	1 (m:1125)
Glossophaginae																			
Anoura caudifer						2	3								1			2	0
Anoura geoffroyi#			4												5		2		3 (f:1135, 1139;m:1147)
Glossophaga soricina	1		2	2	6			5		2	6				2	6	3	14	5 (f:1104, 1112, 1148, 1155; m:1132)
Carolliinae																			
Carollia perspicillata		7		2				4	1		11				10	123	87	62	4 (f:1152; m:1085,1096, 1110)
Rhinophylla pumilio																4	5	4	1 (f:1103)
Stenodermatinae																			
Artibeus fimbriatus##														1	3				2 (m:1123, 1131)
Artibeus lituratus														3	7		5		0
Artibeus obscurus			3	2				1									3	8	6 (f:1086, 1145; m:1122, 1141, 1142, 1156)
Artibeus planirostris			2					1					3		4	5	55	2	5 (f:1115; m:1087, 1090, 1138, 1146)
Chiroderma villosum																	1	3	0
Dermanura cinerea																	3	5	1 (m:1118)
Platyrrhinus lineatus	2		1	3	1			2	3						4			1	4 (f:1089; m:1088, 1144, 1154)
*Platyrrhinus recifinus** VU															1				1(f:1095)
Sturnira lilium																			1 (f:1105)
Sturnira tildae																	2	2	1 (m:1116)
Uroderma bilobatum															2		1	6	0
Mormoopidae																			
Pteronotus parnellii				3															1(f:1151)
Molossidae																			
Molossinae																			
Molossops temminckii	1	3	1	2	1														2 (f:1137; m:1149)
Molossus rufus##										1									1 (m:1079)
Molossus molossus												1				3			2 (f:1107; m:1102)
Cynomops planirostris#				3															1 (m:1150)
Vespertilionidae																			
Vespertilioninae																			
*Eptesicus diminutus*** DD			1																1 (f:1143)
Myotinae																			
Myotis nigricans										1	2	4							4 (f:1124, 1082; m:1084,1083)
Total number of individuals	**7**	**12**	**15**	**24**	**18**	**3**	**2**	**14**	**4**	**8**	**20**	**6**	**5**	**6**	**51**	**145**	**193**	**131**	**664**
Total number of species	**5**	**4**	**8**	**9**	**6**	**1**	**1**	**6**	**2**	**5**	**4**	**3**	**2**	**4**	**15**	**8**	**16**	**14**	**30**

studies with different sampling efforts, similar trends were also observed in this study concerning the most common species.

Compilation data from the Caatinga (Oliveira et al. 2003) reported *G. soricina, A. lituratus, A. planirostris, C. perspicillata, Molossus molossus* and *P. lineatus* as the most common species. In this study, *C. perpicillata* (12%), *G. soricina* (8%) and *Myotis nigricans* (7%) were the most frequent bats, following the general biome characteristics, as well as *M. nigricans*. This present study brought to 41 the number of bat species for the Caatinga in Bahia, with two new formal reports for this region: *A. fimbriatus* and *Molossus rufus*. Only one female adult of *A. fimbriatus* was captured in Manoel Vitorino in January 2010 and one male adult of *M. rufus* was captured in Riacho de Santana in October 2009.

Artibeus fimbriatus occurs from northeastern to southern Brazil, absent only from the northern region (Peracchi et al. 2011). Although most of its records are from tropical rainforests (Araújo and Langguth 2010), it was captured in open arboreal Caatinga. *Molossus rufus* is widely distributed in Brazil, occurring in 19 states of five Brazilian biomes and it has already been reported for the Caatinga biome and for the state of Bahia (Peracchi et al. 2011).

A compilation by Faria and collaborators (2006), including different sampling techniques, systematic and sporadic surveys and a variety of habitats, reported 59 bat species for the southern Bahia rainforest. With the employment of 10,800 $m^2 \cdot h$ sampling effort, Falcão (2007) updated to 60, the bat species for the southern Bahia rainforest, adding *Diaemus youngi* (Phyllostomidae). According to Faria and collaborators (2006), *C. perspicillata* was the most netted species, occurring in 93% of all 14 studied southern Bahia localities, and *G. soricina* was captured in 79% of the municipalities. Adding data from the three rainforest areas in this present report (Itagibá, Uruçuca and Ilhéus), two species of *Anoura* (*A. caudifer* and *A. geoffroyi*) were more common, totaling 71.2% of the 469 individuals surveyed, followed by four *Artibeus* species (*A. fimbriatus, A. lituratus, A. obscurus* and *A. planirostris*) and *Dermanura cinerea* (=*Artibeus cinereus*), summing 18.8%.

Tocantins is one of the least surveyed Brazilian states. Gregorin and collaborators (2011) reported 39 species for the Serra Geral do Tocantins Ecological Station and adjacent areas, 29 of which were first records for the state. Three of them — *A. planirostris, D. rotundus* and *Eptesicus diminutus* — were also captured in this present study. The large number of new records indicates how badly surveyed Tocantins state is and elevates the known bat diversity for the state to 56 species, including these two new records.

Anoura geoffroyi is widely distributed in Brazil, occurring in 17 states in all Brazilian biomes (Peracchi et al. 2011). It was already reported for Pará, Mato Grosso, Goiás and Bahia states (Peracchi et al. 2011), being its occurrence in Tocantins expected. Collected individuals of *A. geoffroyi* had a narrow and hairy interfemoral membrane, without tail, with forearm and cranial measurements larger than *A. caudifer* – the other species that occurs in Brazil (Tamsitt and Nagorsen 1982; Muchhala et al. 2005; Ortega and Alarcón 2008).

Table 3. Morphometrics of collected specimens. M = male; F = female. FA: forearm; Pha: phalanx; Ct: total length of skull; Cb: condylobasal length; lpo: postorbital breadth; lz: zygomatic breadth; lcx: braincase breadth; lcan: breadth of upper canines taken from the outer sides; Lm: width of mandible; Cm: length of mandible.

	Anoura geoffroyi		***Cynomops planirostris***
Sex	M (1)	F (2)	M (1)
FA	42.07	41.51–42.92	31.24
Digit IV 1ª Pha	-	-	11.66
Digit IV 2ª Pha	-	-	4.62
Ct	24.70	24.76–25.11	15.79
Cb	23.89	24.20–24.33	15.12
Lpo	5.40	5.18–5.25	3.94
Lz	10.96	10.84–10.89	10.16
Lcx	9.89	9.70–9.77	7.90
Lcan	4.29	4.35–4.50	4.35
Lm	6.19	6.06–6.24	6.89
Cm	16.89	16.98–17.67	10.44

Cynomops planirostris occurs in 22 Brazilian states, including Amazonia, in the Caatinga, Pantanal and Atlantic Forest (Peracchi et al. 2011). It was already reported for the states of Bahia, Mato Grosso, Pará and Maranhão (Peracchi et al. 2011), so occurrence in Tocantins was also expected. The individual collected had dorsal coloration dark and venter pale, length of forearm, phalanx of digit IV and cranial measurements also corresponded to the species diagnosis (Simmons and Voss 1998; Gregorin and Taddei 2002; Fabian and Gregorin 2007).

Although this project has not sampled exhaustively each study site, it covered a large area through different physiognomies, contributing to increase the knowledge on regional bat lists in poorly known areas of Brazil.

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Appendix 1

Description of areas

Fi: This area is located between Figueirópolis and Sucupira municipalities. The study site is mainly covered with Cerrado, ranging from dense grassland, usually with a sparse covering of shrubs and small trees, to almost closed woodland with a canopy.

Pe: This study site is located in Peixe municipality, right side of Tocantins River. Plain relief, subjected to seasonal floods, covered with savannah park influenced by moisture.

Pr: This study site is located in Paranã municipality, right side of Palmas River. It harbors a mosaic of savannah park.

CT: Important remnants of savannah park located along Palmas River, between Arraias and Conceição do Tocantins municipalities.

Co: Isolated remnant of deciduous forest, thin soil and rocky outcrop.

SD9: Located in São Desidério municipality on the left arm of Estiva or Galheirão river. Open arboreal savannah, with grassland and small trees around 5 to 7 m high, sparsely distributed.

SD10: Located in São Desidério municipality near Rio Grande river. Covered with savannah park influenced by moisture.

SFC: Located in São Félix do Coribe, right arm of Arrojado river, near Santana and Santa Maria da Vitória municipalities. Main vegetation is deciduous forest.

SR: Located in Serra do Ramalho near Bom Jesus da Lapa municipality, transition between Cerrado and Caatinga, left arm of São Francisco river. Main vegetation is Caatinga and deciduous

woodland.

RS: Located near the Riacho de Santana, Matina and Palmas de Monte Alto municipalities, along rio das Rãs. Main vegetation is open arboreal Caatinga.

Ca: Located in Caetité municipality, on Serra do Espinhaço. Main vegetation is closed arboreal Caatinga, thick woodland. It is characterized by a long dry season and a short rainy season.

LR: Located between Livramento de Nossa Senhora and Lagoa Real municipalities, right arm of São João river. Main vegetation is closed arboreal Caatinga.

Br: Located in Brumado near Livramento de Nossa Senhora, right arm of São João river. Main vegetation is closed arboreal Caatinga.

MV: Located in Manoel Vitorino near Iramaia municipality, right arm of rio das Contas. Main vegetation is thick arboreal Caatinga. It is characterized by a long dry season and a short rainy season.

Je: Located in Jequié near Itagi municipality, left arm of rio das Contas, Main vegetation is semi-deciduous forest, canopy up to 13 m high, emergent trees around 20 m, understory around 3 m high.

It: Located in Itagibá near Ipiaú municipality, right arm of rio das Contas. Main vegetation is rainforest with Caatinga specimens and other typical species of forest formations of southern Bahia.

Ur: Located in Uruçuca near Ilheús municipality, along São José river. Main vegetation is rainforest mixed with "cabruca", agroforestry systems in which cocoa trees (*Theobroma cacao*) are planted under the forest canopy for shade with Caatinga specimens and other typical species of forest formations of southern Bahia.

Il: Located in Ilhéus municipality. Main vegetation is rainforest mixed with "cabruca". Predominant species in moist environments have low density of individual trees.